

Kinetic Pathways for Phase-Selective Growth of Indium Selenides by Molecular Beam Epitaxy

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Abstract

Indium selenides (In_xSe_y) are layered III–VI semiconductors exhibiting rich polymorphism and phase-dependent electronic and optical properties that make them attractive for optoelectronic, ferroelectric, and energy-related applications [1,2]. However, reproducible phase control during molecular beam epitaxy (MBE) remains challenging because narrow thermodynamic stability windows and competing growth pathways often result in mixed phases and degraded material quality. In this work, we demonstrate two complementary kinetic approaches for phase-selective growth of indium selenides by MBE on technologically relevant substrates. First, surfactant-mediated growth with a controlled tin flux on Si (100) modifies surface kinetics by preferentially interacting with selenium, thereby altering the local Se/In ratio at the growth front. This kinetic modulation suppresses the nucleation of $\gamma\text{-In}_2\text{Se}_3$ and stabilizes single-phase $\gamma\text{-InSe}$, as confirmed by X-ray diffraction (XRD) and Raman spectroscopy [3]. Second, flux-timing control using periodic interruptions of the indium flux under constant selenium overpressure induces transient selenium-rich surface conditions that suppress γ -phase formation and promote the stabilization of phase-pure $\beta\text{-In}_2\text{Se}_3$ on c-plane sapphire substrates [4]. Structural and vibrational analyses reveal clear phase selectivity associated with the indium-flux interruption intervals, while optical microscopy and atomic force microscopy indicate improved morphological uniformity. These results demonstrate that kinetic control through surfactant mediation and temporal flux modulation provides an effective strategy for selecting polymorphs in layered indium selenides. The approach offers a pathway for phase engineering in layered chalcogenides and supports their scalable integration in future electronic and optoelectronic devices.

References

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